Satellite Image,
Source for Terrestrial Information,
Threat to National Security

by

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MANIT TRAINING PROGRAMME

on

Information Security

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Bhopal – 462 016

The Maulana Azad National Institute of Technology (MANIT), Bhopal, conducted a short term course on "Information Security", Dec. 10 -14, 2007. The institute invited me to deliver a lecture. I preferred to talk on ***"Satellite Image - source for terrestrial information, threat to national security".*** I extended my talk around 50 slides, tried to give an over view of Imaging satellites, Globalization of terrestrial information and views express about National security. Highlights of my talk were:

- *Remote sensing, Communication, and the Global Positioning satellite Systems;*
- *Concept of Remote Sensing;*
- *Satellite Images Of Different Resolution;*
- *Desired Spatial Resolution;*
- *Covert Military Line up in 1950s;*
- *Concept Of Freedom Of International Space;*
- *The Roots Of Remote Sensing Satellites;*
- *Land Remote Sensing Act of 1992;*
- *Popular Commercial Earth Surface Imaging satellites -*
  Landsat , SPOT and Pleiades , IRS and Cartosat , IKONOS , OrbView & GeoEye, EarlyBird, QuickBird, WorldView, EROS;
- *Orbits and Imaging characteristics of the satellites;*
- *Other Commercial Earth Surface Imaging satellites –*
  KOMPSAT, Resurs DK, Cosmo/Skymed, DMCii, ALOS, RazakSat, FormoSAT, THEOS;
- *Applications of Very High Resolution Imaging Satellites;*
- *Commercial Satellite Imagery Companies;*
- *National Security and International Regulations –*
  United Nations , United States , India;
- *Concern about National Security - Views expressed;*
- *Conclusion.*

Satellite Image,
Source for Terrestrial Information,
Threat to National Security

- *Remote sensing satellites, Communication satellites, and the Global Positioning System (GPS)* together have immense strategic value. The capabilities derived from these systems are driving the commercial engine of the new information-based economy.

- Uses for ***Remote Sensing Imageries***, range from the military (reconnaissance, mapping, damage assessment), to the commercial (farming, mining, real estate), the humanitarian (human rights abuses) and environmental catastrophe.

  Similarly, ***Satellite communications***, have connected businesses located on opposite sides of the globe as well as increased the capacity and speed of command and control links on the battlefield.

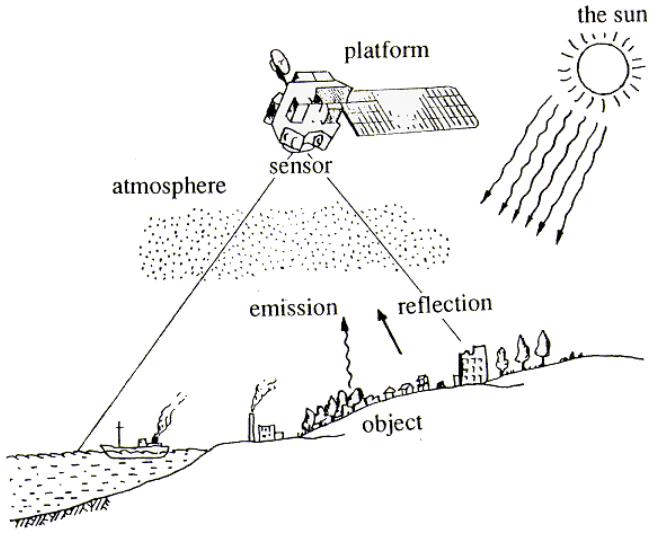
  Finally, the ***Global Positioning Systems*** have significantly enhanced precision targeting and troop coordination also improved airline safety, the tracking of vehicles and many more.

Satellite systems have dual use - both civil and military. The governments and businesses around the world recognize the immense value, the satellite applications can offer them. *The satellite industry traditionally dominated by programs run with government funding are now controlled by commercial interests.* Even military for their operational necessity have now been looking for ways to save money by absorbing private sector capabilities rather than preferring expensive classified systems.

The proliferation of satellite technology is largely because of commercial interests. The revenue form the commercial satellite market is growing fast in both the United States and worldwide. In 1996 global satellite industry revenues were around $37.5 billion (U.S. $19 billion), was estimated to reach $82.6 billion in 2000. According to satellite industry associations, the U.S. satellite industry revenues represent nearly half of worldwide revenues. The figures include commercial communications satellite services, launch services, manufacturing of satellites and ground equipment, as well as sale of remote sensing imagery and value-added services. The satellite services and applications alone represents around two-thirds of space industry revenues. The industry associations estimated, that the global commercial satellite service revenues will more than triple by 2009. One good reason is that *satellite images are most preferred source for terrestrial information.* ***[http://www.fas.org/spp/eprint/article06.html , Commercial Space and United States National Security]***

Concept of Remote Sensing

Remote Sensing is a technology by which the characteristics of objects of interest can be identified, measured or analyzed without direct contact.



Remote Sensing systems include :

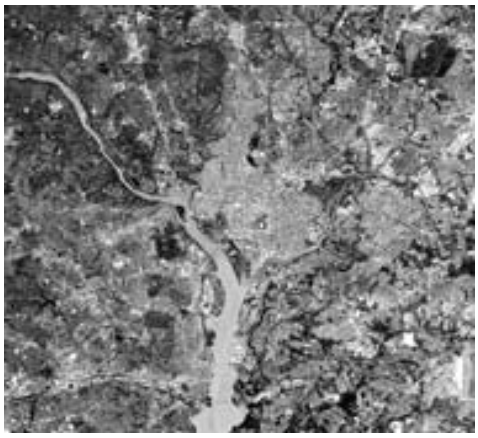
- **Source :** Electro-magnetic radiation which is reflected or emitted from an object is the usual source of remote sensing data.
- **Sensor :** A device to detect the electro-magnetic radiation reflected or emitted from an object; e.g. - Cameras or scanners.
- **Platform:** A vehicle that carries remote sensor; e.g. - aircrafts or satellites.
- **Output :** Data usually an *Image* .

The Remote sensing data are processed by computer and interpreted by humans, and then finally utilized in agriculture, land use, forestry, geology, hydrology, oceanography, meteorology, environment etc.

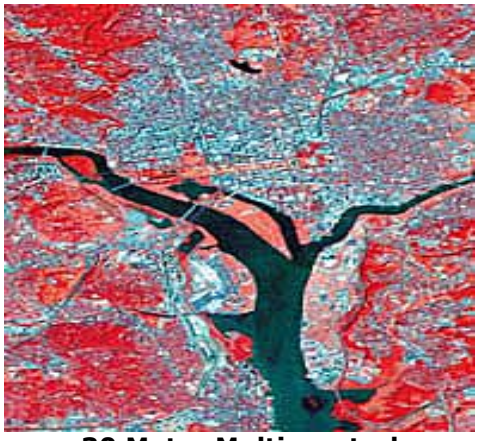
Satellite Images Of Different Resolution

Below shown for the purpose of comparison the *satellite images of four different spatial resolutions – 1, 10, 30 and 80 meter.* All images are centered at same target; because the images are of same size, the decrease in resolutions are seen with increase in area covered.

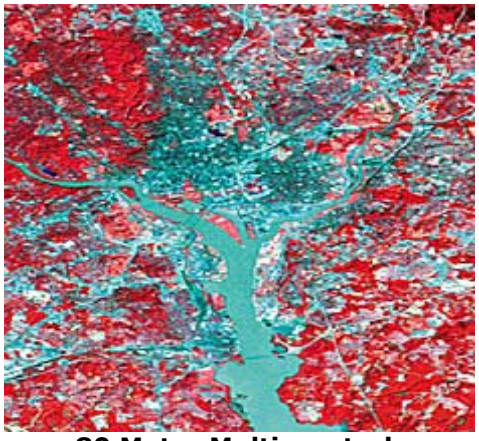
1 Meter Panchromatic



10 Meter Panchromatic



30 Meter Multispectral



80 Meter Multispectral

Desired Spatial Resolution

The *spatial resolutions required for detection, location, identification, and differentiation of objects on Earth surface* are indicated below.

One-Meter

Identify and Map : manhole covers, automobiles, bus shelters, highway lanes, sidewalks, utility equipment, fence lines, and free-standing trees and bushes.

Identify : characteristics features of many of above mentioned objects.

Detect : small areas of stress in farm fields or tree stands.

Locate and Map : houses, roads, buildings, courtyards, and small farm fields.

Differentiate : among types of buildings and houses.

10-Meter

Locate and Map : buildings, yards, roads, property boundaries, athletic fields, farm fields, and side streets.

Differentiate : farm fields, tree stands and relative vegetative health.

Make : small-area land-cover classifications.

20/30-Meter

Locate : airports, city centers, suburbs, shopping malls, sports complexes, large factories, forest stands, and large farm fields.

Make : generalized land-cover classifications.

80-Meter

Map : regional geological structure.

Assess : vegetative health in a large region.

1-Kilometer

Assess : vegetative indices for states and entire countries.

Track : events like - insect infestation, drought and desertification.

Covert military line up in 1950s

From mid-1940s to early 1990s was the period of tension, competition and conflict known as cold war between the United States and the Soviet Union. Let us *recall few events occurred between 1950 and 1960*.

- In early 1950s, U.S thought of an ***Spy plane U-2*** to photograph a particular location, knowingly violating a country's airspace. The plane would fly at 70,000 feet, beyond the reach of Soviet fighters and missiles, and also outside the range of radar detection, equipped with imaging sensors, either wet film photo, electro-optic or imaging radar.

- In 1955, U.S. offered to Soviet Union an ***"Open Skies"*** policy, allowing mutual territorial surveillance which was not agreed by the later.

- In 1956, U.S. stated ***U-2 fly-over program***, secretly gathered data on Soviet missile capabilities, knowingly violating the country's airspace. For four years, the U-2's cameras took photos of ICBM testing sites and air bases.

- In October 1957, ***"Sputnik" the first satellite*** was successfully launched by Soviet Union

- On May 1, 1960 the spy plane ***U-2 came to crisis,*** shot down over the Soviet Union. The U.S. denied the true purpose of the plane.

- Thus, *U.S. faced two unsuccessful initiatives* :
  (a) the "Open Skies" policy offered to Soviet Union in 1955, was rejected
  (b) the *"U-2 fly-over program"* , aborted in 1960 because direct aerial observation means violating that country's airspace.

- In August 1960, U.S. *secretly developed* ***"Discoverer XIV"****, a spy satellite* and recovered its first film capsule.

- Interpretation : ***In a way "Sputnik orbit" tacitly legitimized pictures from over-flight in space***.

Concept Of Freedom Of International Space

Soon after Sputnik was launched in 1957, the *U.S. perceived, that the Soviet Union unintentionally established the concept of freedom of international space.*

U.S. talked about peaceful uses of space for the benefit of mankind, while pursuing military applications. In a way, U.S. showed concern for both power and legitimacy. For example :

- **Launch of First satellite as a scientific project :** U.S. on March 17, 1958, launched Vanguard-1, the first artificial satellite with a scientific experiment into orbit around the Earth as part International Geophysical Year (July 1, 1957 to Dec. 31, 1958). *Thus U.S. became the champion of openness, international cooperation, and the rule of law in space.*

- **Campaign for Reconnaissance satellites :** Necessary for gathering reliable information about military developments behind the iron curtain, to negotiate arms control and to retain defense sufficiency in the absence of agreements. This is *likely only if usage of imaging satellites are legitimatized.*

Note :

1. *The launching of Sputnik was also planned as part of the IGY, but Soviet Union launched the satellite using a military intercontinental ballistic missile.* ***The Sputnik launch went against the plan to use non-military rocket and satellite designs and deployments to collect data during the IGY.***
2. *The IGY was over on Dec. 31 1958.* ***The scientific community learned from the satellite based experiments of the benefits*** *of the international scientific cooperation. the scientists of different disciplines once worked in isolation found common ground and new paths to invention. Eventually, the public began to see the benefits of these scientific endeavors in their daily lives.*

The Roots Of Remote Sensing Satellites

Remote Sensing refers to viewing Earth from space across the visible and other spectra. There are three main facets of Remote Sensing : (1) Image resolution; (2) Satellite's repeat/revisit days; and (3) Sensor's spectral coverage. *The image resolution is a critical component that largely decides its military utility.*

The commercial potential of remote sensing satellites were envisaged much before the fall of Soviet Union (1991). NASA launched the civilian remote sensing satellite ***Landsat*** in 1972, that provided the satellite images of resolution *80 meter* of Earth to the non-governmental sector. But soon this new technology became untenable for the private sector to sustain and derive profit. The effectiveness of *Landsat* suffered because of low resolution. *Landsat* eventually, languished over a decade before a commercial market sufficient to make it profitable materialized.

But then U.S. space industry faced new challenge in *1986*. It lost the superpower monopoly, because of economic competitiveness. A more capable French Imaging competitor launched remote sensing satellite ***SPOT-1*** in February 1986, followed by **SPOT-2** in January 1990. The image resolutions were *10 meter*.

The competition became more while India launched ***IRS-1A*** in 1988 and ***IRS-1B*** in 1991. The image resolutions were *36 meter*. While these two satellites offered resolution less than SPOT but then ***IRS-1C*** and ***IRS-1D*** were slated for launch in 1995 and 1997. These two satellites were expected to capture images of resolution *5.8 meter*.

The result was, in the year 1992, *U.S. declared new initiative – known as Land Remote Sensing Act of 1992.*

Land Remote Sensing Act of 1992

This act enabled U.S. to maintain its leadership in land remote sensing by:

- providing data continuity for the *Landsat program*,
- establishing a new national Land Remote Sensing Policy,
- implementing a fundamental change, rejecting full commercialization in favor of a more long-term, and protective development of the remote sensing industry under the guidance of the DoD and NASA.

The relevant extracts from this act of 1992: *Sec.2 Findings*, *Sec.3 Definitions , and Sec.103 Data Policy* are stated below.

◇ **Extracts from Sec. 2. Findings :** declared

- The continuous collection and utilization of land remote sensing data from space are of major benefit in studying and understanding human impacts on the global environment, in managing the Earth's natural resources, in carrying out *national security functions*, and in planning and conducting many other activities of scientific, economic, and social importance.
- Full commercialization of the *Landsat* program cannot be achieved within the foreseeable future, ... *commercialization of land remote sensing* should remain a long-term goal of U.S. policy.
- Development of the remote sensing market and the provision of commercial value-added services based on remote sensing data should remain exclusively the function of the private sector.

◇ **Extracts from Sec. 3. Definitions :** apply

- The term `*Landsat system' means Landsats 1, 2, 3, 4, 5, and 6*, and any follow-on land remote sensing system operated and owned by the United States Government, along with any related ground equipment, systems, and *facilities owned by the United States Government*.
- The term `*Landsat 6 contractor' means the private sector entity* which was awarded the contract for spacecraft construction, operations, and data marketing rights for the Landsat 6 spacecraft.
- The term `*Landsat 7*' means the follow-on satellite to *Landsat 6.*

◇ **Extracts from Sec. 103 : Data policy for *Landsat* 4 through 6**

Landsat Program Management shall enter into negotiations with the *Landsat 6* contractor to formalize pricing, distribution, acquisition, archiving, and availability of un-enhanced data**.**

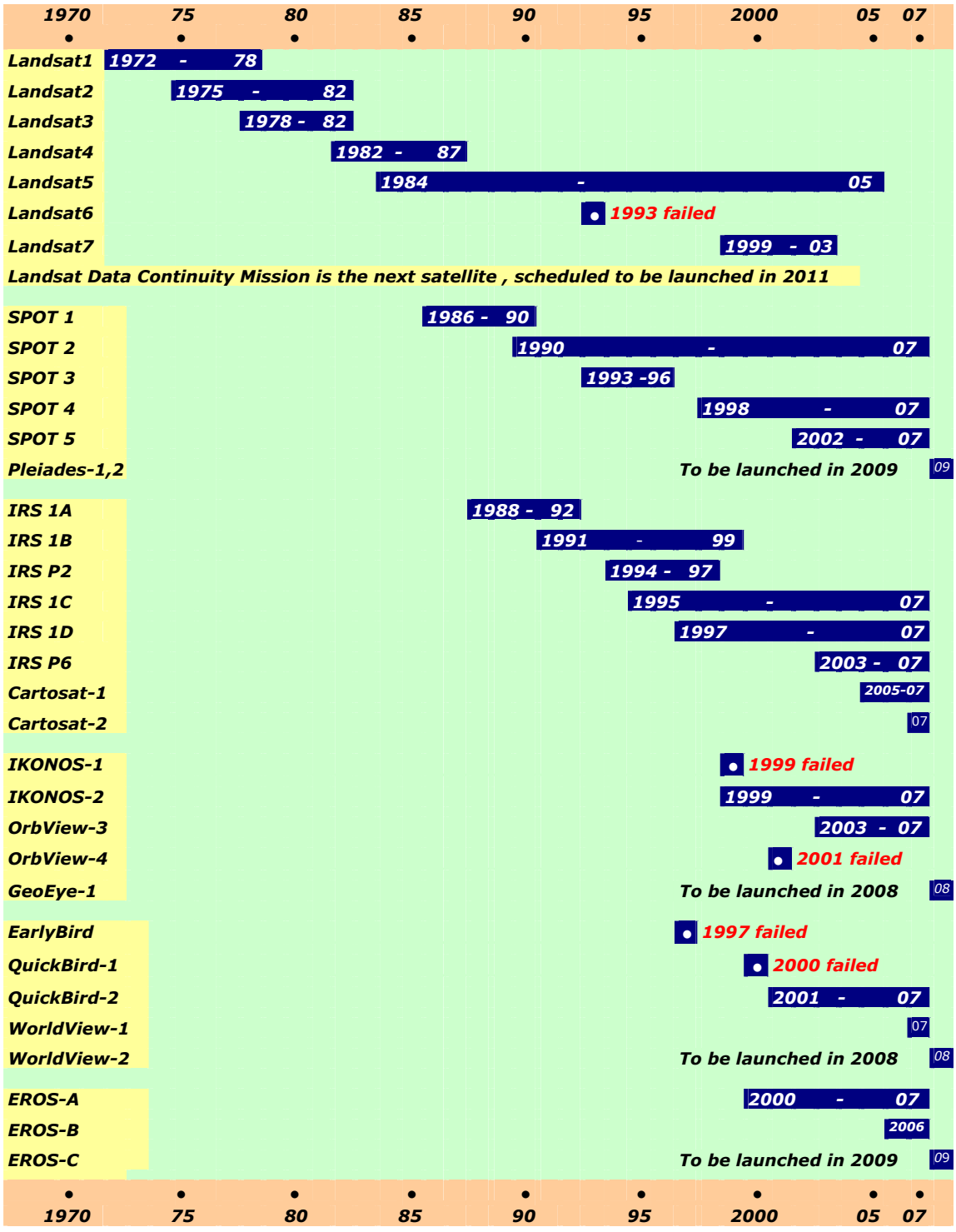
- Un-enhanced data shall be provided, . . . , to the United States Government and its affiliated users . . . , on the condition that such un-enhanced data are used solely for noncommercial purposes;
- *Landsat* data users are able to acquire un-enhanced data contained in the collective archives of foreign ground stations as easily and affordably as practicable;
- United States Government and its affiliated users shall not be prohibited from reproduction or dissemination of un-enhanced data to other agencies of the United States Government and other affiliated users, on the condition . . . . . used solely for noncommercial purposes;
- *A viable role for the private sector in the promotion and development of the commercial market* for value added and other services . . . . is preserved;
- Un-enhanced data from the *Landsat* system are provided to the National Satellite Land Remote Sensing Data Archive . . . .

Popular Commercial Earth Surface Imaging satellites

To acquire images of Earth from space, many satellites were launched starting from the year 1972. The series of *satellites owned by countries – U.S.A, France, India, and Israel* are shown below.

Landsat, SPOT, IRS, IKONOS, OrbView, GeoEye, QuickBird, WorldView, EROS

Year of launch / termination/failure



Orbits and Imaging characteristics of the satellites

Landsat, SPOT, IRS, IKONOS, OrbView, GeoEye, QuickBird, WorldView, and EROS series of satellites, their launch, status, resolution, swath, repeat cycle, altitude, inclination and onboard communication are indicated.

◇ *Landsat 1 , 2 , 3, 4 , 5 , 6, 7*

The satellites *Landsat* 1 through 7 were launched in last 27 years, starting from the year 1972. *Landsat*-7 offers *15 meter resolution*.

Satellite	*Launch*	*Status till date Dec. 2007*
Landsat 1	**23. 07. 1972**	***operation ceased on Jan. 1978;***
Landsat 2	**22. 01. 1975**	***operation ceased on Feb. 1982;***
Landsat 3	**05. 03. 1978**	***operation ceased on Nov. 1982;***
Landsat 4	**16. 07. 1982**	***Sensors not operational after July 1987***
Landsat 5	**01. 03. 1984**	***went to crisis in Dec. 2005; resumed in Jan. 2006***
Landsat 6	**05. 10. 1993**	***failed to reach orbit;***
Landsat 7	**15. 04. 1999**	***Faulty scan line on May, 2003;***

The orbit and Imaging characteristics : Mostly same for all satellites, except image resolutions that were constantly improved from 80 to 15 meter .

- Sun-synchronous, near-polar orbit
  Equatorial crossing time between 9.30 to 10 AM +/- 15 minutes
- Resolution, Swath, Revisit

Satellite	*Resolution Meter*		*Swath Km*	*Resolution Meter*		*Swath KM*	*Repeat days*	*Altitude KM*	*Inc deg*	*Comm. Equ.*
Landsat 1 *1972 – 78*	**80**	**RBV**	**185**	**80**	**MSS**	**185**	**18**	**917**	**99.2**	**DD, VTR**
Landsat 2 *1975 – 82*	**80**	**RBV**	**185**	**80**	**MSS**	**185**	**18**	**917**	**99.2**	**DD, VTR**
Landsat 3 *1978 – 82*	**80**	**RBV**	**185**	**80**	**MSS**	**185**	**18**	**915**	**99.1**	**DD, VTR**
Landsat 4 *1982 – 87*	**30**	**TM**	**185**	**80**	**MSS**	**185**	**16**	**705**	**98.2**	**DD, TDRSS**
Landsat 5 *1984 – 2005*	**30**	**TM**	**185**	**80**	**MSS**	**185**	**16**	**705**	**98.2**	**DD, TDRSS**
Landsat 6 *1993*	**15**	**PAN**	**185**	**30**	**ETM**	**185**	***Failed to reach orbit***			**DD, TR**
Landsat 7 *1999 – 2003*	**15**	**PAN**	**185**	**30**	**ETM**	**185**	**16**	**705**	**98.2**	**DD, TR**

- *Archived millions of scenes of U.S. and world over*.
- A unique resource for global change research.
- Applications in agriculture, cartography, geology, forestry, regional planning, surveillance, education and national security.

◇ SPOT 1, 2, 3, 4, 5, Pleiades-1, 2

The satellites *SPOT* 1 through 5 were launched in last 16 years, starting from 1986. *SPOT*-5 offers *2.5 meter resolution*. The *Pleiades* is France's high-resolution imaging satellite. It would offer images of *0.7 meter* resolution. The program, is supervised by *CNES*, the France Space Agency. *Pleiades* is part of European Earth Remote Sensing program.

Satellite	Launch	Status till date Dec. 2007
SPOT 1	22. 02. 1986	Operation ceased in 1990; decommissioned in 2003.
SPOT 2	22. 01. 1990	in real-time operation; TRs failed in 1991 & 1993;
SPOT 3	26. 09. 1993	terminated in 1996;
SPOT 4	24. 03. 1998	in operation ;
SPOT 5	03. 05. 2002	in operation;
Pleiades-1	slated for late 2009	
Pleiades-2	slated for 2010	

The orbit and Imaging characteristics : Mostly same for all satellites, except image resolutions that were constantly improved from 10 to 2.5 meter.

- Sun-synchronous, near-polar orbit

  Equatorial crossing time 10.30 AM +/- 15 minutes

- Resolution, Swath, Revisit

Satellite	Resolution		Swath	Resolution		Swath	Repeat	Altitude	Inc	Comm. Equ.
	Meter		Km	Meter		KM	days	KM	deg	
SPOT 1 1986 – 90	10	PAN	117	20	MSS	117	26	832	98.7	DD, TR
SPOT 2 1990 –	10	PAN	117	20	MSS	117	26	826	98.7	DD, TR
SPOT 3 1993 – 96	10	PAN	117	20	MSS	117	26	823	98.7	DD, TR
SPOT 4 1998 –	10	PAN	117	20	MSS	117	26	826	98.7	DD, TR
SPOT 5 2002 –	2.5/5	PAN	117	10	MSS	117	26	822	98	DD, Memory
Pleiades-1	0.7	PAN	20	2.8	MSS	20	26 To be launched in 2009	695	98.2	DD, Memory
Pleiades-2	0.7	PAN	20	2.8	MSS	20	26 To be launched in 2010	695	98.2	DD, Memory

- Applications in Land use, agriculture, forestry, geology, cartography, regional planning, etc. The objective is global coverage and a daily observation accessibility to any point on Earth;
- *Dual use civil and military*.

◇ IRS 1A , 1B, P2, 1C, 1D, P6, P5, Cartosat-2

The IRS satellites 1A through cartosat-2 were launched in last 19 years, starting from the year 1988. *Cartosat-2* offers *< 1 meter resolution*.

Satellite	Launch	Status till date Dec. 2007
IRS 1A	17. 03. 1988	mission completed in 1992
IRS 1B	29. 08. 1991	mission completed in 1999
IRS P2	15. 10. 1994	mission completed in 1997
IRS 1C	28. 12. 1995	in operation;
IRS 1D	29. 09. 1997	in operation;
ResSat-1 (P6)	17. 10. 2003	in operation;
Cartosat1 (P5)	05. 05. 2005	in operation;
Cartosat2	10. 01. 2007	in operation;

The orbit and Imaging characteristics : Mostly same for all satellites, except image resolutions that were constantly improved to from 36 to < 1 meter.

- Sun-synchronous, near-polar orbit

  Equatorial crossing time 10.30 AM +/- 15 minutes

- Resolution, Swath, Revisit

Satellite	Resolution Meter		Swath Km	Resolution Meter		Swath KM	Repeat days	Altitude KM	Inc deg	Comm. Equ.
IRS 1A 1988-92	36	MSS	74x2	72.5	MSS	148	22	904	99	DD, TR
IRS 1B 1991-99	36	MSS	74x2	72.5	MSS	148	22	904	99.4	DD, TR
IRS P2 1994-97	36	MSS	66x2				24	817	98.7	DD, TR
IRS 1C 1995-	5.8	PAN	70	23.5	MSS	142	24	817	98.6	DD, TR
IRS 1D 1997-	5.8	PAN	70	23.5	MSS	142	25	737, 821	98.3	DD, TR
ResSat-1, P6 2003-	5.8	MSS	70	23.5	MSS	140	24	817	98.6	DD, TR
Cartosat1 P5 2005-	2.5	PAN	30	2.5	PAN	30	126	618	97.8	DD, TR
Cartosat-2 2007-	< 1	PAN	9.6				310	630	97.9	DD, Memory

- Applications in crop land and yield estimation, survey of forest resources, urban mapping, flood mapping, wasteland mapping and drought monitoring and assessment.

◇ Ikonos, OrbView , GeoEye

Lockheed Martin in 1991 started a Remote Sensing Imaging Satellite project CRSS. *The objective was to offer commercial high-resolution (1m PAN and 4 m MSS) images* with location knowledge in near real-time and offline. The project went through many changes.

- In 1994, a new company "*Space Imaging*" was formed with partners, LMMS, Raytheon/E-Systems, Eastman Kodak Co.
- In 1995, *Space Imaging* was awarded a license to construct, launch and operate a two satellites. The company acquired EOSAT (a joint venture of Lockheed Martin and Hughes Aircraft), later became ***Space Imaging Inc***.
- On April 27, 1999, Ikonos-1 launched by *Space Imaging* failed.
- On Sept. 24, 1999, ***Ikonos-2*** was successfully launched. The company began to sell Ikonos-2 imagery.
- On June 26, 2003, ***OrbView-3*** was launched by OrbImage Inc.
- In Sept. 2005, OrbImage acquired Space Imaging; the merged company was named ***GeoEye Inc.***
- The Ikonos-2 spacecraft is now owned and operated by GeoEye. This company operates the imaging missions OrbView-2, OrbView-3, and GeoEye-1 in future.
- In early 2008, ***GeoEye-1*** is scheduled for launch by GeoEye Inc.

Ikonos, OrbView, GeoEye

The satellites Ikonos, OrbView, and GeoEye are commercial remote sensing systems. Five satellites were launched, two failed, in last 8 years, starting from the year 1999. *GeoEye-1* would offer *0.41 meter resolution*.

Satellite	Launch	Status till date Dec. 2007
Ikonos-1	**27. 04. 1999**	***Failed to reach orbit***
Ikonos-2	**24. 09. 1999**	***in operation;***
OrbView-2	**01. 08. 1997**	***in operation;***
OrbView-3	**26. 06. 2003**	***went on crisis in Mar. 2007;***
OrbView-4	**21. 09. 2001**	***Failed to reach orbit***
GeoEye-1 *(OrbView-5)*	**slated for second quarter 2008**	

The orbit and Imaging characteristics : Mostly same for all satellites except swath; the image resolutions are constantly improved, from 1 to 0.41 meter.

- Sun-synchronous, near-polar orbit

  Equatorial crossing time 10.30 AM +/- 15 minutes

- Resolution, Swath, Revisit

Satellite	Resolution Meter		Swath Km	Resolution Meter		Swath KM	Repeat days	Altitude KM	Inc deg	Comm. Equ.
Ikonos-1 *1999*	**1**	**PAN**	**13**	**4**	**MSS**	**13**	***Failed to reach orbit***			**DD, Memory**
Ikonos-2 *1999-*	**1**	**PAN**	**13**	**4**	**MSS**	**13**	**14**	**681**	**98.1**	**DD, Memory**
OrbView-2 *1997-*	***Non imaging, for detection of Ocean & Environment conditions***							**700**	**98.2**	**DD, Memory**
OrbView-3 *2003-2007*	**1**	**PAN**	**8**	**4**	**MSS**	**8**	**< 3**	**470**	**97.2**	**DD, Memory**
OrbView-4 *2001*	**1**	**PAN**	**8**	**4**	**MSS**	**8**	***Failed to reach orbit***	**470**		**DD, Memory**
GeoEye-1	**0.41**	**PAN**	**15.2**	**1.4**	**MSS**	**15**	**To be launched in 2008**	**660**		**DD, Memory**

- Applications : Used for national security, military mapping, air and marine transportation.
- As of October 2007, *Images of more than 300 million square kilometers of the Earth's surface have been archived.* To view some images readers may click at URL *http://www.satimagingcorp.com/gallery-ikonos.html*, Satellite Image Corporation.

◇ EarlyBird, QuickBird, WorldView

In 1992 the *WorldView* Imaging Corporation was formed as a *commercial business enterprise* with the idea of converting space-based weapons system technology into a viable earth-observation system. It went through many changes.

- In 1993, *WorldView* was granted license to build a commercial remote sensing satellite.
- In 1995, the *WorldView* and the Commercial Remote Sensing Efforts of *Ball Aerospace* merged and formed ***EarthWatch Inc*** .
- On Dec. 24, 1997, *EarthWatch Inc* launched ***EarlyBird-1*** (using Russian rockets). Four days later, the communication was lost with *EarlyBird-1*.
- On Nov. 20, 2000, *EarthWatch* Inc launched ***QuickBird-1*** (using Russian rockets) which was destroyed in the launch failure.
- In sept. 2001 *EarthWatch Inc* changed its name to ***DigitalGlobe***.
- On Oct. 18, 2001, *DigitalGlobe* successful launched ***QuickBird-2*** using Delta-2 vehicle of Boeing from Vandenberg Air Force Base, USA.
- On Sept. 18, 2007, *DigitalGlobe* successful launched ***WorldView-1***.
- In early 2008, ***WorldView-2*** is scheduled for launch by *DigitalGlobe.*

EarlyBird, QuickBird, WorldView

The satellites EarlyBird, QuickBird, WorldView are commercial remote sensing systems. Four satellites were launched, two failed, in last 10 years, starting from the year 1997. *WorldView-1* offers 0.45 meter resolution.

Satellite	Launch	Status till date Dec. 2007
EarlyBird-1	**24. 12. 1997**	***Four days later Failed; lost communication;***
QuickBird-1	**20. 11. 2000**	***Failed to reach orbit;***
QuickBird-2	**18. 10. 2001**	***in operation;***
WorldView-1	**18. 09. 2007**	***in operation;***
WorldView-2 **slated for early 2008**		

The orbit and Imaging characteristics : Mostly same for all satellites except swath; the image resolutions are constantly improved, from 3 to 0.46 meter.

- Sun-synchronous, near-polar orbit
  Equatorial crossing time 10.30 AM +/- 15 minutes
- Resolution, Swath, Revisit

Satellite	Resolution Meter		Swath Km	Resolution Meter		Swath KM	Revisit days	Altitude KM	Inc deg	Comm. Equ.
EarlyBird-1 *1997*	**3**	**PAN**	**11.1**	**15**	**MSS**	**55.5**	***Four days later Failed***			**DD, Memory**
QuickBird-1 *2000*	**1**	**PAN**	**13**	**4**	**MSS**	**13**	***Failed to reach orbit***	***600***		**DD, Memory**
QuickBird-2 *2001-*	**0.61**	**PAN**	**16.5**	**2.5**	**MSS**	**16.5**	**1-3.5**	**450**	**98**	**DD, Memory**
WorldView-1 *2007-*	**0.45**	**PAN**	**17.6**					**496**	**97.2**	**DD, Memory**
WorldView-2	**0.46**	**PAN**	**16.4**	**1.8**	**MSS**	**16.4**	**To be launched in 2008**	**770**		**DD, Memory**

- Applications : Provides highly detailed imagery for precise map creation, precise change detection and in-depth image analysis; mapping at unprecedented resolutions in multi-spectral imagery, and opens door to creation of numerous new products.
- By 2008, DigitalGlob's constellation of satellites will enable commercial and government customers around the globe to access geospatial information products from a single source. *WorldView-1 alone is capable of collecting up to 500,000 square kilometers per day of half-meter imagery.*

◇ EROS-A, EROS-B, EROS-C

Earth Resources Observation Satellite (EROS) is a series commercial Earth observation satellites, designed and manufactured by Israel Aircraft Industries (IAI). The optical payload is supplied by, Elbit Systems Ltd, one of Israel's largest defense electronics manufacturers and integrators. The space borne remote sensing technology for the EROS family was approved by the *government of Israel* in Oct. 1996.

- The satellites are owned and operated by ***ImageSat International (ImageSat)***, another Israeli company.
- On Dec. 5, 2000, ***EROS-A*** was launched on the Russian *Start-1* launcher from the Svobodny Launch Complex in eastern Siberia.
- On April 25, 2006, ***EROS-B*** was launched on the Russian *Start-1* launcher from the Svobodny Launch Complex in eastern Siberia.
- In 2009, ***EROS-C*** is planned for launch, and its optical resolution has still not been decided.
- *ImageSat* has announced plans to launch 3 more satellites in later dates, to provide full coverage of the entire planet surface with 6 functional satellites.

EROS-A, EROS-B, EROS-C

The satellites EROS-A, EROS-B, and EROS-C are commercial remote sensing systems. Two satellites were launched in last 6 years, starting from the year 2000. *EROS-2* offers 0.45 meter resolution.

Satellite	Launch	Status till date Dec. 2007
EROS-A	**05. 12. 2000**	**in operation;**
EROS-B	**25. 04. 2006**	**in operation;**
EROS-C	**slated for early 2009**	

The orbit and Imaging characteristics : Mostly same for all satellites except swath; the image resolutions are constantly improved, from 1.8 to 0.7 meter.

- Sun-synchronous, near-polar orbit
  Equatorial crossing time 10.30 AM +/- 15 minutes
- Resolution, Swath, Revisit

Satellite	Resolution Meter		Swath Km	Resolution Meter		Swath KM	Revisit days	Altitude KM	Inc deg	Comm. Equ.
EROS-A *2000-*	**1.8**	**PAN**	**14**				**2.5-4.5**	**500**	**97.4**	**DD, Memory**
EROS-B *2006-*	**0.7**	**PAN**	**14**					**500**	**97.2**	**DD, Memory**
EROS-C	**0.7**	**PAN**	**11**	**2.8**	**MSS**	**11**	**500 To be launched in 2009**			**DD, Memory**

- Applications : The objective is to launch and operate a constellation of high-resolution *commercial satellites, primarily for intelligence and national security applications and to serve a global customer base.*
- Among the diverse applications for EROS imagery are: Air Forces, Naval Forces, Ground Forces, Homeland Security / Border Control, Mapping, Environment and Disaster Control, and Infrastructure.
- Launch date plans for *EROS-B* were to use it to monitor Iran's developing nuclear program for potential threats to Israeli security. An image taken by the EROS A showed US Air Force B-52 bombers and KC-135 tankers aircraft at the Indian Ocean island of Diego Garcia. Readers may see some images at URL : http://www.imagesatintl.com/ .

Other Commercial Earth Surface Imaging satellites

Only few countries, *USA, France, India, and Israel have highly efficient commercial Earth remote sensing programs*. They offer image ***resolution 1 meter and less***. More importantly, they regularly supplement the space segment with new satellite and hold the positions as the primary suppliers of space data.

Many other countries, *Korea, Russia, Italy, U.K., JAPAN, Malaysia, Taiwan, and Thailand* also have high resolution satellites. The launch, orbit and Imaging characteristics of these satellites are indicated below. These satellites have ***resolutions 2.5 to 1 meter***, considered comparatively less and thus the applications for which they are used.

Satellite	Resolution Meter		Swath Km	Resolution Meter		Swath KM	Repeat days	Altitude KM	Inc deg	Country
KOMPSAT 2 *28.07.2006*	***1***	***PAN***	***15***	***4***	***MSS***	***15***	***28***	***685***	***98.1***	***Korea/ Israel***
Resurs DK1 *15.06.2006*	***1***	***PAN***	***28***	***2.5***	***MSS***	***28***		***350x610***	***70***	***Russia***
Cosmo/Skymed-1 *08. 06. 2007* ***Cosmo/Skymed-2*** *08. 06. 2007* ***Cosmo/Skymed-3,4*** *2008 and later*	***Constellation of four Synthetic Aperture Radar satellites, multi mode - resolution 1, 3-15, 15, 30, 100 meters and swath 1, 40, 30, 40, 100, 200 km., to observe anywhere on the Earth, in all weather and day/night conditions.***						***16***	***619***	***97.8***	***Italy***
DMC International Imaging (DMCII) [Second generation DMC satellites] *2008, 2009*	***Disaster Monitoring constellation(DMC)- Five satellites each built in the UK, and operated by the countries that own them: Algeria, China, Nigeria, Turkey and UK. The constellation would image any part of the world on any given day. Daily revisit, wide swath 600 km and resolution MSS 32 meter and later 22 meter, PAN 4 meter.***									***U.K.***
ALOS *24. 01. 2006 –*	***2.5***	***PAN***	***35/70***	***10***	***IR***	***70***	***46***	***694***	***98.2***	***JAPAN***
RazakSat *Early 2008*	***2.5***	***PAN***	***20***	***5***	***MSS***	***20***	***1 to 4 times daily***	***685***	***9***	***Malaysia***
FormoSAT-2 *(ROCSat-2 renamed) 20. 05. 2004*	***2***	***PAN***	***24***	***8***	***MSS***	***24***	***daily***	***891***	***99.1***	***Taiwan***
THEOS *Early 2008*	***2***	***PAN***	***22***	***15***	***MSS***	***90***	***26***	***822***	***98.7***	***Thailand***

Applications of Very High Resolution Imaging Satellites

The very *high resolution, 1 meter and less, satellites* are owned by *U.S.A*, followed by *Israel*, *India, France*, *Russia, and Korea/Israel*.

	Country	Agency (Owing, Operating, Controlling)	No of Satellites	Satellites (Image Res. 1 meter or less)	Last launch/ scheduled
1.	U.S.A	GeoEye Inc a Commercial Imaging Company	3	Ikonos-2	24. 09. 1999
				OrbView-3	26. 06. 2003
				GeoEye-1	Mid 2008
		DigitalGlobe Inc a Commercial Imagery and Geo-spatial Information company	3	QuickBird-2	18. 10. 2001
				WorldView-1	18. 09. 2007
				WorldView-2	Early 2008
2.	Israel	ImageSat International N.V. a commercial provider of earth-imagery	2	EROS-B	25. 04. 2006
				EROS-C	Early 2009
3	India	ISRO , NRSA and ANTRIX Corporation Limited	1	Cartosat-2	10. 01. 2007
4.	France	CNES (French space agency), an international co-operation	2	Pleiades-1	Early 2009
				Pleiades-2	2010
5.	Russia	Roscosmos - Federal Space Agency of the Russian Federation	1	Resurs DK1	15.06.2006
6.	Korea/ Israel	KARI (Korea Aerospace Research Institute), Spot Image exclusive distributor	1	KOMPSAT 2	28.07.2006

The typical military application of images acquired by these Commercial Civilian Remote Sensing satellites are illustrated in next few slides. The *targets of military interest* are:

bridges, radar, supply dumps, troop units, airfield facilities, rockets and artillery, aircraft, command & control HQ., missiles (ssm/sam), surface ships, nuclear weapons components, vehicles, minefields (land), ports and harbors, coasts and landing beaches, railroad yards and shops, roads, urban areas, terrain, submarines (surfaced).

Targeting is closely related to the ability to *detect* and *precisely identify* the given object and/or their location.

◇ Image Resolution : 1 meter

Imaging satellites : *Ikonos-2 (1999), OrbView-3 (2003) , Cartosat-2 (2007) offer 1 meter resolution.*

- Resolution 1 meter is considered enough to :

  Detect : all most any military utility; means location of a class of units, objects, or activity of military interest.

  Identify : all most any military utility; means determining their general target type.

  In fact, all military utility can be precisely identified, except few say – radar, supply dumps, rockets and artillery, missiles (SSM/SAM), surface ships, nuclear weapons components, vehicles.

  Describe : Few military utility, like bridges, ports and harbors, coasts and landing beaches, railroad yards and shops, roads, urban areas, terrain, submarines (surfaced);

  means their size/dimension, configuration/layout, component construction, and equipment count, etc.

- Resolution 1 meter is not enough to:

  Analyze : any specific military entity

◇ Image Resolution : 0.6 – 0.7 meter

Imaging satellites: *QuickBird-2 (2001) offer 0.6 meter resolution*; and

Imaging satellites: *EROS-B (2006), EROS-C (2009) , Pleiades-1 (2009) , Pleiades-2 (2010) , offer 0.7 meter resolution.*

– This resolution is considered enough to :

Detect : *all most any military utility; means location of a class of units, objects, or activity of military interest.*

Identify : *all most any military utility; means determining their general target type.*

In fact, all military utility can be precisely identified except very few say – radar, supply dumps, rockets and artillery, nuclear weapons components, vehicles.

Describe : *few military utility, like - bridges, ports and harbors, coasts and landing beaches, railroad yards and shops, roads, urban areas, terrain, submarines (surfaced).*

means their size/dimension, configuration/layout, component construction, and equipment count, etc.

– This resolution is even enough to:

Analyze : *few military utility, like – urban areas, terrain,*

◇ Image Resolution : 0.4 meter

Imaging satellites: *WorldView-1 (2007), WorldView-2 (2008) and GeoEye-1 (2008) offer 0.4 meter resolution.*

– This resolution is considered enough to :

Detect : *all most any military utility; means location of a class of units, objects, or activity of military interest.*

Identify : *all most any military utility; means determining their general target type.*

In fact, all military utility can be precisely identified except - Nuclear Weapons Components, Vehicles

– This resolution is enough to :

Describe : *few military utility, like - bridges, ports and harbors, coasts and landing beaches, railroad yards and shops, roads, urban areas, terrain, submarines (surfaced).*

means their size/dimension, configuration/layout, component construction, and equipment count, etc.

– This resolution is even enough to:

Analyze : *few military utility, like – bridges, ports and harbors, railroad yards and shops, roads, urban areas, terrain, submarines (surfaced).*

Commercial Satellite Imagery Companies

Viewing Earth from space have become necessary for every country. Therefore, the world market of Geo-data and Space Imagery have grown and would continue to grow towards Globalization of Terrestrial Information. The *United States, Israel, India, and France,* hold the world market for satellite based earth imagery. They run highly efficient operational Earth Remote Sensing programs. They regularly supplement the space segment with new satellite and become primary suppliers of earth imagery.

- They follow different models, e.g. United States follow the commercial model, France and *Israel* follow public-private partnership, and India follow state funding.
- They have different perception, interpretation and views about National Security vis-a-vis Economic, Commercial, Technology and other interest.

Thus, the approaches they follow in their projects/programs (for developing, funding, owning, controlling and marketing) ultimately decides the growth of the space imagery market.

These countries and their respective agencies responsible for satellite based earth imagery are reiterated here.

	Country	**Agency (Owing, Operating, Controlling)**
1.	*USA*	*USGS and NASA* *GeoEye Inc* *DigitalGlobe Inc*
2.	*Israel*	*ImageSat International N.V.*
3.	*India*	*ISRO , NRSA and ANTRIX Corporation Limited*
4.	*France*	*CNES (French space agency)*

Their approaches and commercial tie-up are stated below.

◇ USGS and NASA : A joint Initiative

- National Aeronautics and Space Administration (NASA) develops and launch the *Landsat spacecrafts* ;
- U.S. Geological Survey (USGS) handles the operations, maintenance, and the management of all ground data reception, processing, archiving, product generation, and world wide distribution.

◇ GeoEye Inc : Private Remote Sensing System Company

GeoEye Inc, Headquartered in Dulles, Virginia, USA, is a commercial satellite imagery company, provides high quality, accurate imagery and products to map, measure, monitor and manage the world. *GeoEye provides* ***Microsoft and Yahoo! search engines*** *253 million square kilometers of satellite map images.*

- The company provides geospatial data, information and value-added products for the national security community, strategic partners, resellers and commercial customers.
- The company own and operates a constellation of three Earth imaging satellites : *IKONOS-2 (1999), OrbView-2 (1997), OrbView-3 (2003), GeoEye-1 (2008) and an International network of a dozen ground stations*, a robust image archive, and advanced geospatial imagery processing capabilities.
- The company's products are enabling a wide array of applications including intelligence gathering for national security and defense, mapping, local government planning, and natural resources and environmental monitoring.
- GeoEye is a public company listed on the NASDAQ stock exchange under the symbol GEOY.

◇ DigitalGlobe Inc : Private Remote Sensing System company

DigitalGlobe, headquartered in Longmont, Colorado with locations in Washington D.C., is a world wide supplier of high-resolution commercial satellite imagery. *DigitalGlobe is the premier provider of imagery in* ***Google's database*** *(Google Maps, Google Earth*).

- DigitalGlobe own and operate satellites *QuickBird-2 (2001), WorldView-1 (2007) and WorldView-2 (2008).*
- DigitalGlobe´s constellation of satellites enables commercial and government customers around the globe to access a broad selection of geospatial information products from a single source.
- DigitalGlobe´s system features allow it to efficiently *collect over 475 million square kilometers of imagery data annually.* Thus, DigitalGlobe populates and updates its image library with impressive speed.

◇ ImageSat International NV : An International Company

ImageSat International N.V. ("ImageSat") is a Netherlands Antilles company with offices in Limassol, Cyprus and Tel Aviv, Israel. The Company's offices in Tel Aviv supervise the construction of the EROS family of satellites and the operations of ImageSat's main Ground Control Station.

- ImageSat is an international (non U.S.) company.
- ImageSat's principal business is operating high-resolution satellites and *providing exclusive, autonomous high-resolution satellite imaging services to* ***Governments and their Defense Forces*** *for National Security and Intelligence applications.*
- ImageSat is a commercial provider of high-resolution, satellite earth-imagery collected by its Earth Remote Observation Satellite (EROS).
- ImageSat own and operate satellites *EROS-A (2000), EROS-B (2006), and EROS-C (2009) .*
- ImageSat has partnered with a global network of ground receiving station operators, value-added information processors to supply EROS imagery data worldwide. These are :

ImageSat Israel, Ltd. Tel-Aviv , ***Israel****;*

Russian Federation, R&D Center ScanEx , Moscow, ***Russia****;*

IPT Informatica per il Territorio S.r.l., Rome ***Italy****;*

Earth Environment Info. Center - Hiroshima Inst. of Tech., Hiroshima, ***Japan****;*

Center for Space & Remote Sensing Research, National Central University ***Taiwan****;*

Comision Nacional de Actividades Espaciales, Paeso Colon , ***Argentina****;*

CSIR/Satellite Applications Center SAC-icomtek, Pretoria, ***South Africa****;*

MDA Geospatial Services Inc ,* ***Canada****;*

APOGEE Imaging International , Lobethal,* ***Australia****;*

Space Consulting S.A. Athens,* ***Greece****;*

[Note : ImageSat Distributors, at Canada, Greece and Australia currently does not serve as a ground receiving station.]

◇ CNES : Public Estt. of Industrial and Commercial character

The Centre National d'Etudes Spatiales (CNES) is administratively a public establishment of industrial and commercial character.

- CNES owns and operates the SPOT satellite system.
- *SPOT IMAGE Corp. a private company and others of USA hold the worldwide commercial operations.*
- SPOT-5 is publicized as dual purpose serving both military and civil needs.

Pleiades High Resolution Program : An International Co-Operation

Pleiades High Resolution Program is held under the supervision of CNES Space Agency of France since 2000 as a part of the European Earth Remote Sensing program.

- *Pleiades is an international co-operation to meet the needs of civilian and military users.* The program is publicized as dual purpose serving both military and civil needs.
- On January 29, 2001, an agreement was signed between the French and Italian governments concerning Earth Observation co-operation, on a dual system serving both military and civil needs.
- The implementation of military space policy in France involves cooperation between both military and civilian agencies.
- France's military space program focuses primarily on advanced Remote sensing satellites.

◇ ISRO /NRSA / ANTRIX Corporation : Government of India

Indian Space Research Organization (ISRO) was established in 1969, under Department of Space (DOS), Government of India.

- *ISRO, Government of India*, builds, launch and maintain the Remote Sensing Earth Observation satellites.
- *National Remote Sensing Agency (NRSA), an autonomous organization under DOS,* is responsible for acquisition, processing, supply of aerial and satellite remote sensing data.
- NRSA also supports, through ANTRIX, establishment of International Ground Stations and International reseller network to receive, process and market data products globally.
- ANTRIX Corporation Limited, is the a leading provider of satellite images worldwide and the marketing arm of ISRO under DOS.
- *Antrix Corporation is marketing space products and services in the global market.* Twenty four stations including USA (10) and Russia (4), across the globe now receive IRS data. In addition to RESOURCESAT-1 and CARTOSAT-1 and the latest satellite, CARTOSAT-2, have further enhanced the scope and continuity of Indian earth observation satellite data services.
- The world archive of satellite data is being created through the archive station at Svalbard, Norway, which has been used as a virtual ground station for processing of CARTOSAT-1 data. A number of resellers have been appointed for data sale to countries including Canada, Greece and Turkey.

National Security and International Regulations

Space-based Remote Sensing consists of collecting data regarding the surface of the earth via satellite. The information gathered from such data can be used in many applications. The commercial availability of high-resolution *imagery presents both a great benefit to civilian sector and a deep concern for national security.* Such paradox is true every where, it is true even for military users.

[The military is benefited from access to high-resolution commercial imagery, potentially saving it the billions of dollars required to produce, field and operate such space-based remote-sensing systems. There is a dark side, just as the military have access to high-resolution commercial imagery, so will the general public and foreign entities, allies and adversaries alike. Without proper protections, military movement and buildup, the lay-out of military facilities and even the locations of individual pieces of military equipment could be made available to the public eye within a matter of hours. This could have grave consequences for military operations and national security.]

A solution if it is - ***Strike a balance between profitability and protection;***

i.e., profitability to industry and protection to national security respectively.

The International Regulations related to National Security are illustrated :

- United Nations Treaties and Principles on Space Law
  [http://www.unoosa.org/oosa/en/SpaceLaw/treaties.html]

- U.S. National Space Policy
  [http://www.globalsecurity.org/space/library/policy/national/index.html]

- *ISRO:EOS:POLICY-01:2001, Remote Sensing Data Policy (RSDP) , Indian Space Research Organisation*
  [http://www.isro.org/Announcement-opportunity/rdsp.pdf]
  [http://www.nrsa.gov.in/policy.html]

◇ United Nations Treaties and Principles on Space Law

[http://www.unoosa.org/oosa/en/SpaceLaw/treaties.html]

The Committee on the Peaceful Uses of Outer Space is the only international forum for the development of international space law. It has concluded international legal instruments and legal principles governing space-related activities. Extracts from the treaties and agreements are reproduced here.

▪ Principles Relating to Remote Sensing of the Earth from Outer Space

[http://www.unoosa.org/oosa/en/SpaceLaw/gares/html/gares_41_0065.html]

[resolution 3234 (XXIX) of 12 November 1974, the question of the legal implications of remote sensing of the Earth from space, with the aim of formulating draft principles relating to remote sensing. After a lengthy debate over whether remotely sensed data should be internationally available, the UNGA adopted the UN Remote Sensing Principles in the form of a non-binding Resolution on January 22, 1987.]

Principle II : *. . for the benefit and in the interests of all countries, irrespective of . . economic, social or scientific technological development . . ;*

Principle III : *Remote sensing activities shall be conducted in accordance with international law . . . ;*

Principle IV : *. . . activities . . on the basis of respect for . . sovereignty of all States and peoples over their own wealth and natural resources . . . , rights and interests, in accordance with international law, . . . Such activities shall not be conducted in a manner detrimental to the legitimate rights and interests of the sensed State;*

Principle V : *States carrying . . . activities shall promote international co-operation . . . . shall make available to other States opportunities for participation therein. Such participation shall . . . on equitable and mutually acceptable terms;*

Principle VI : *. . . to maximize the availability of benefits . . . States are encouraged, through agreements . . . establishment and operation of data collecting and storage stations and processing and interpretation facilities, ...;*

Principle VII : *States participating . . . activities shall make available technical assistance to other interested States on mutually agreed terms;*

Principle VIII : *The United Nations . . . shall promote international co-operation, including technical assistance and co-ordination in the area of remote sensing;*

Principle IX : *. . . article IV of the Convention on Registration of Objects Launched . . . and article XI of the Treaty on Principles Governing the Activities of States in the Exploration . . . , a State carrying out . . . remote sensing shall inform the . . . United Nations. . . . make available . . . relevant information . . . feasible and practicable to any other State, particularly any developing country that is affected by the programme, at its request.*

Principle X : *Remote Sensing shall promote the protection of the Earth's natural environment . . . .States . . . having identified information . . . that is . . . harmful to the Earth's natural environment shall disclose . . . to States concerned.*

Principle XI : *Remote sensing shall promote the protection of mankind from natural disasters. . . . States . . . that have identified . . . information . . . useful to States affected . . . or likely to be affected by impending natural disasters, shall transmit such data and information to States concerned as promptly as possible.*

Principle XII : *As soon as . . . data concerning the territory under its jurisdiction are produced, the sensed State shall have access to them on a non-discriminatory basis and on reasonable cost terms. The sensed State shall also have access to the available analysed information concerning the territory under its jurisdiction in the possession of any State participating in remote sensing activities . . . taking particularly into account the needs and interests of the developing countries.*

Principle XIII : *To promote . . . international co-operation, . . . , a State carrying out remote sensing . . . upon request, enter into consultations with a State whose territory is sensed . . . make available opportunities for participation and enhance the mutual benefits to be derived therefrom.*

Principle XIV : *In compliance with article VI of the Treaty on Principles Governing the Activities of States in the Exploration . . . , States operating remote sensing satellites shall bear international responsibility for their activities and assure that such activities are conducted in accordance with these principles and the norms of international law, irrespective of whether such activities are carried out by Governmental or non-governmental entities or through international organizations to which such States are parties. . . .;*

Principle XV : Any dispute resulting from the application of these principles shall be resolved through the established procedures for the peaceful settlement of disputes.

◇ U.S. National Space Policy

[http://www.globalsecurity.org/space/library/policy/national/index.html]

- *National Space Study Center – law , doctrine and policy*
  [http://space.au.af.mil/doctrine.htm]

- *Fact Sheet Foreign Access To Remote Sensing Space Capabilities - March 10, 1994, The White House Office of the Press Secretary*
  [http://www.au.af.mil/au/awc/awcgate/space/pdd-23.htm]

- *Fact sheet National Space Policy - september 19, 1996, The White House National Science And Technology Council (Obsolete as of 31 Aug 2006)*
  [http://www.au.af.mil/au/awc/awcgate/sep96.htm]

- *A National Security Strategy of Engagement and Enlargement - February 1996, The White House (replaces previous editions of 1994 and 1995)*
  [http://www.globalsecurity.org/space/library/policy/national/1996stra.htm]

- *U.S. national security and government regulation of commercial remote sensing from outer space – 2001, Air Force Law Review, Wntr, 2001 by Michael R. Hoversten.*
  [http://findarticles.com/p/articles/mi_m6007/is_2001_Wntr/ai_75622168]

- *Fact Sheet U.S. Commercial remote sensing policy - April 25, 2003, Office of Science and Technology Policy(OSTP)*
  [http://www.au.af.mil/au/awc/awcgate/space/2003remotesensing-ostp.htm]
  (This policy supersedes Presidential Decision Directive 23, U.S. Policy on Foreign Access to Remote Sensing Space Capabilities, dated 9 March 1994.)

- *Fact Sheet U.S. Commercial Remote Sensing Space Policy - May 13, 2003, The White House, Office of the Press Secretary*
  [http://www.au.af.mil/au/awc/awcgate/space/2003remotesensing-ostp.htm]
  [http://www.globalsecurity.org/space/library/policy/national/space-030513-wh-8.htm]
  (last policy covering this area was issued in 1994)

- ***U.S. National Space Policy - Aug 31. 2006, released Oct 06 2006, The White House , Office of Science and Technology Policy***
  http://www.ostp.gov/html/US%20National%20Space%20Policy.pdf
  http://www.au.af.mil/au/awc/awcgate/whitehouse/ostp_space_policy06.pdf
  http://www.globalsecurity.org/space/library/policy/national/us-space-policy_060831.htm
  (This policy supersedes Presidential Decision Directive/NSC-49/NSTC-8, National Space Policy, dated September 14, 1996.)

  [The "Commercial Space Guidelines" at S.No 7 and "International Space Cooperation" at S.No. 8 are of immediate concern; readers may visit the site and read]

◇ ISRO:EOS:POLICY-01:2001, Remote Sensing Data Policy (RSDP) , Indian Space Research Organisation

[http://www.isro.org/Announcement-opportunity/rdsp.pdf]
[http://www.nrsa.gov.in/policy.html]

The Department of Space (DOS) of the Government of India is the nodal agency for all actions under this policy. For acquisition/distribution of remote sensing data within India, license/permission from the Government of India, through the nodal agency, will be necessary.

- National Remote Sensing Agency (NRSA) of the DOS is vested with the authority to acquire and disseminate all satellite remote sensing data in India – both from Indian and foreign satellites.
- Government prescribes the following guidelines to be adopted for dissemination of satellite remote sensing data in India:

  (a) All data of resolutions up to 5.8 m shall be distributed on a nondiscriminatory basis and on "as requested basis";

  (b) With a view to protect national security interests, all data of 5.8 m and better than 5.8 m resolution images will be screened by the appropriate agency before distribution so that images of sensitive areas are excluded.

  (i) Data of 5.8m and up to 1m resolution can be distributed to users after screening and ensuring the sensitive areas are excluded.

  (ii) Data of 1m resolution and better will also be screened as above and the following procedure will be followed for its distribution.

  1. Government users can obtain the data without any further clearance.
  2. Private sector agencies, recommended by at least one Government agency for use of 1m and better resolution data for supporting development activities, can obtain it without any further clearance.
  3. Other Private, Foreign and other users can obtain the data after further clearance from an inter-agency High Resolution Image Clearance Committee (HRC).
  4. Specific requests for data of sensitive areas, by any user, can be distributed only after obtaining clearance from HRC.
  5. Specific sale/non-disclosure agreements to be concluded between NRSA and users for data of 1 m resolution and better.

This policy comes into effect immediately and may be reviewed from time-to time-by Government.

Concern about National Security - Views expressed

[http://www.internationalreporter.com/news/read.php?id=1863]

[http://myreaders.wordpress.com/2007/06/04/17/]

The views reported in the world wide web about security related challenges and threat because high resolution images are available commercially or even freely in public domain.

Security concern expressed by Govt. of India

The then President A P J Abdul Kalam, while addressing the National Police Academy at Hyderabad in mid-October, 2005, expressed concern over the security threat posed by Google Earth's free mapping program available on the internet.

The Indian Space Research Organization (ISRO) chief Dr. G Madhavan Nair hadexpressed concern at high-resolution satellite images offered by Google.

[Ref : "Google Earth worries ISRO chief, wants dialogue". Press Trust of IndiaNew Delhi, July 8, 2006, HT dated July 9, 2006]

Since then the Chief of Army Staff General J J Singh, Secretary DST Prof V. S. Ramamurthy, Surveyor General Maj. Gen. M. Gopal Rao, and others expressed that it could severely compromise a country's security.

Security concern expressed by experts

Many security experts in and outside the country, even within government have articulated different view. The IDSA expert C. Uday Bhaskar, Sandia National Laboratories Security analyst Vipin Gupta, GlobalSecurity.org Director John Pike, FMNN Privacy Analyst Ravi Visvesvaraya Prasad and others feel :

- "……it is is part of *technology enabling characteristics* of the present times"
- "…… you have multiple eyes in the sky, …… creating a transparent globe where anyone can get basic information about anyone else, …… *accept the new reality*: ……Times are changing, and the best thing to do is adapt to the advances in technology ……";
- "…… June, 2005 launched website http://earth.google.com/, has allowed users *unrestricted access to satellite imagery* that otherwise was hardly ever available to the common man. The sophisticated images capture …… Earth' geography and allow even street level viewing of cities but at the same time feature sensitive military and political sites";
- "*What can the Indian government do* to prevent terrorists or hostile forces from viewing high resolution photographs of its sensitive installations? The answer, in practical terms, is *Absolutely Nothing At All*."
- "…… absolutely *no practical, feasible method at present to prevent* satellites from photographing sensitive Indian sites. The only solution is to camouflage them appropriately, or keep them underground or underwater, as had been done for the Pokharan II blasts."
- "…… call for *limiting access* to http://earth.google.com/ *is also unfeasible*, since potential terrorists can access this website, or other similar websites such as MSN TerraServer, from other countries without any restrictions whatsoever."

- "…… several *other sources from where images of far higher resolutions can be obtained*. *DigitalGlobe's* QuickBird satellite images have resolution 2 feet. The Landsat-7 satellite offers 1.4-metre resolutions of almost any location in the world for just one dollar per twenty square miles. Google's rival, Microsoft, offers services such as *MSN Virtual Earth*, *TerraServer*, and *TerraFly*, similar to *Google Earth*."

- "…… assertion that "developing countries, which are already in danger of terrorist attacks, have been singularly chosen for providing high-resolution images of their sensitive sites, is also not entirely true. *Millions of very high-resolution photographs of US and NATO defence and nuclear installations are available for free at Google Earth*, …… show the White House; the headquarters of USA's National Security Agency at Fort Meade, US chemical weapons depots, US nuclear missile sites, and US and NATO defence bases all over the world in far greater detail."

- "…… *India's defence forces state:* …. we can also access high-resolution photographs of terrorist camps in Pakistan-occupied Kashmir, as well as of Kahuta and Sargodha".

- "…… The Indian government should instead focus on *utilizing the high-resolution photographs for positive purposes* such as meteorology, hurricane and cyclone forecasting, emergency and disaster relief, agricultural and irrigation planning, mineral exploration, oil and gas exploration, monitoring soil erosion and use of river waters, urban planning, etc."

- "…… *Indian civil society is already using data from Google Earth* for positive purposes. Former MP from Mumbai, Kirit Somaiya, said: …… Google Earth made possible the study of the Mithi river, which was responsible for the deaths of more than 600 people during the devastating rain and floods in Mumbai last July …… unplanned development and encroachment along the river banks were the root cause of the disaster …… no governmental agency has a map of the Mithi river at all. …… in all official records, this river does not even exist…"

- "Reuters reports via CNN International. France Challenges Google Earth With New Site JUN 23, 2006 - *French President Jacques Chirac said it's important for his country to have such a site available* because he wants France to keep up with the fast pace of technological innovation today …… "

- " Analysts say the *average traffic* to the most popular French websites is about *four million a day*."

- " A French remote sensing company that specializes in products for intelligence, security, and peacekeeping operations — has issued a study of Google Earth, titled *Google Earth Study: Impacts and Uses For Defence and Security*."

Conclusion

Should we continue such debate or look for solution ?

- Exploring the views, mentioned above, reported in the world wide web about security related challenges vis-a-vis the emerging technology of the present time in creating a transparent globe where anyone can get basic information about anyone else, the general view is :

  Google Earth and their competitors MSN Virtual Earth, TerraServer, and TerraFly and others are trying to bring a revolution in "Globalization of Terrestrial Information" about the world we live in.

  However, I suggest few *measures to safeguard the security aspects*.

  - Google Earth and all their competitors need to *adopt a uniform policy* to render terrestrial details.

  - About *resolution of satellite imageries*, this may be different but what is important is that the resolution should be one and same for a particular class of targets/objects and may have a different resolution for another class of targets/objects. This means, if resolution say "R1" is set for all cartographic features, then the resolution could be 'R2" for all objects of military interest but certainly not "R1" for some military objects and "R2" for other military objects of same country or different country.

  - Thus, the agencies need first to *define/categorize targets/objects classes*: having cartographic features, having military interest, industrial units, power generation units, areas of human settlement, forest region, mountainous terrain, desert region, coastal region, and ocean etc. They then need to *decide on resolutions* one and same or different for the target/object classes.

  - Having defined and categorized targets/objects classes, then take decision on resolutions. The decisions must be uniformly applicable to all countries, irrespective of their geographic location, technology, economy, law and values. The word resolution must not be generalized but mention clearly, *Resolution - Spatial / Radiometric / Spectral / Temporal / Height*.

  - These *suggestions are doable, agreeable and sustainable* forever. The countries having large resources need to serve most and others having limited resources can do their bit.

References : Open sources – mainly internet.

Note :

1. This talk has been prepared, using information available from open sources, mainly internet sources, for bring general awareness about high resolution satellite images. There is no commercial interest, what so ever, is involved.
2. Readers are invited to place their comments.